

# Operational Related Risks

Best Practices in Dam and Levee Risk Analysis

Part H – Other Risks

Chapter H-1

June 2017



US Army Corps  
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# Objectives

## Understand

- The various ways improper or accidental operation can lead to failure
- How to construct and event tree to represent operational risks
- How to feed this information into other failure modes

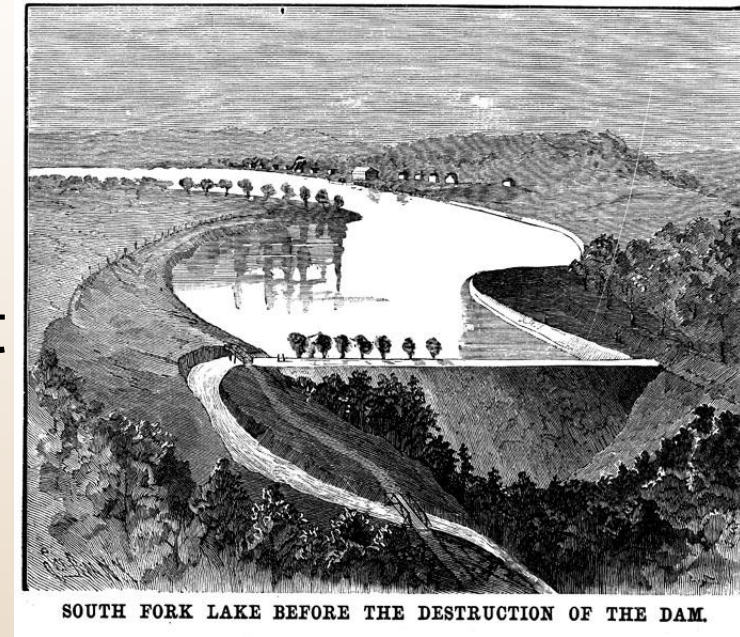
# Key Concepts

- Operator error
- Inadvertent operation
- Gate mis-operation or malfunction
- SCADA and remote operation
- Access
- Barge impact and towboat misadventures
- Water Control Plan
- These are all unique and require some creative thought
- These happen frequently
- This is part of many risk assessments



# South Fork Dam Modifications

- Failed in 1862 - collapse of stone outlet conduit, reconstructed but outlet filled in
- Spillway:
  - Ungated overflow
  - 99 feet wide
  - Bridge across spillway with supports at 6-1/2 foot spacing
  - Iron Screens were placed across the spillway to prevent fish from escaping reduced spillway capacity by 40%
- Dam crest lowered to widen roadway so that carriages could pass
- No camber, center portion of dam crest lower



SOUTH FORK LAKE BEFORE THE DESTRUCTION OF THE DAM.



# South Fork Dam

- Heavy rains in May of 1889
- Inflow greater than spillway capacity and fish screens became plugged with debris
- Dam overtopped and failed



# Failure Consequences, Johnstown, PA



- 2,209 Deaths
- 99 entire families died, including 396 children
- The greatest loss of life due to failure of a man-made structure for a single event in the history of the United States until 9/11.



# Taum Sauk



- Concrete-faced earthfill “ring-dike” structure
- Upper reservoir of pumped-storage project
- Water routinely stored on 10-foot high parapet

# Taum Sauk

- Membrane liner installed in 2004
- Reservoir level instrumentation could not be reinstalled properly due to liner warranty issues
- Instruments were loose and not reading reservoir level properly
- Resetting of reservoir sensors did not account for settlement of embankment
- Alarms wired so high level and high-high level sensors both needed to trigger for alarm
- Over-pumping was not detected and dam overtopped and failed

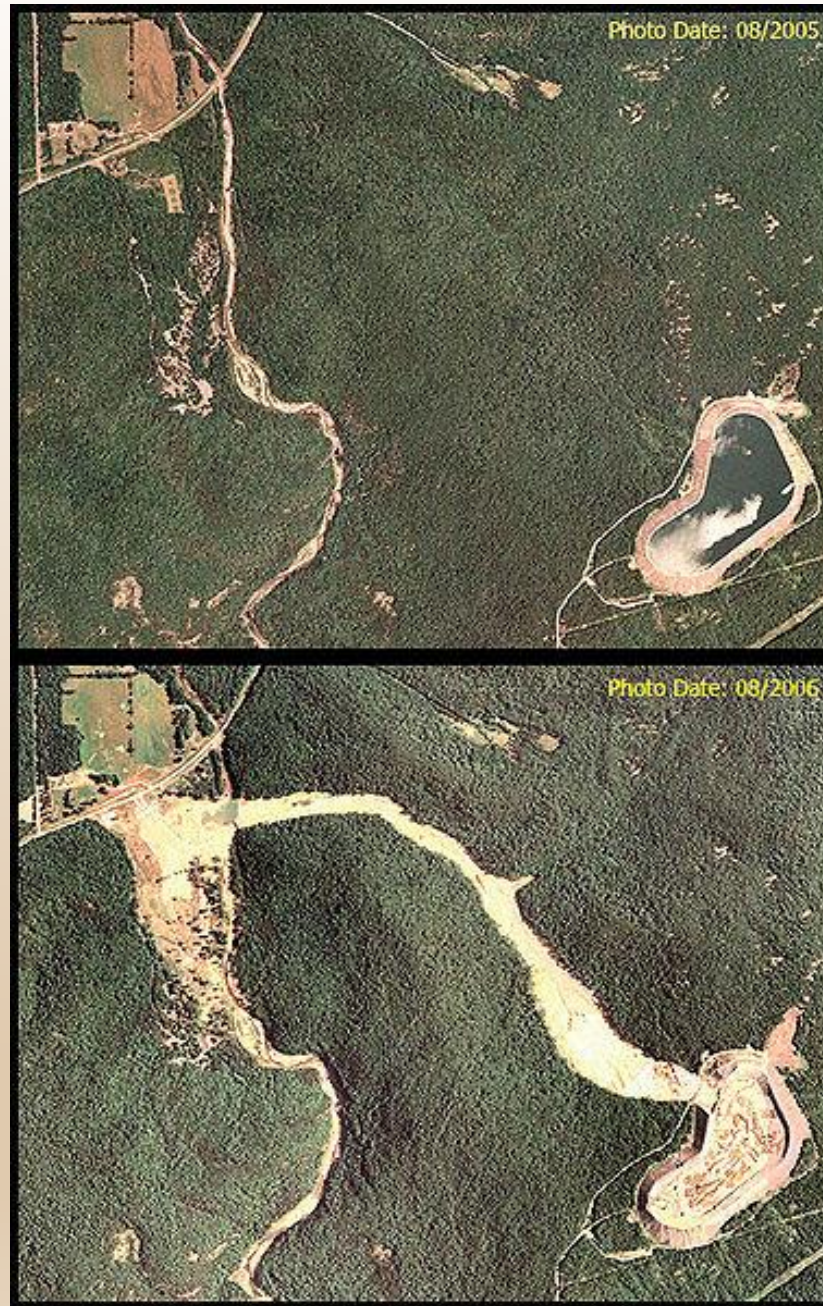




# Taum Sauk



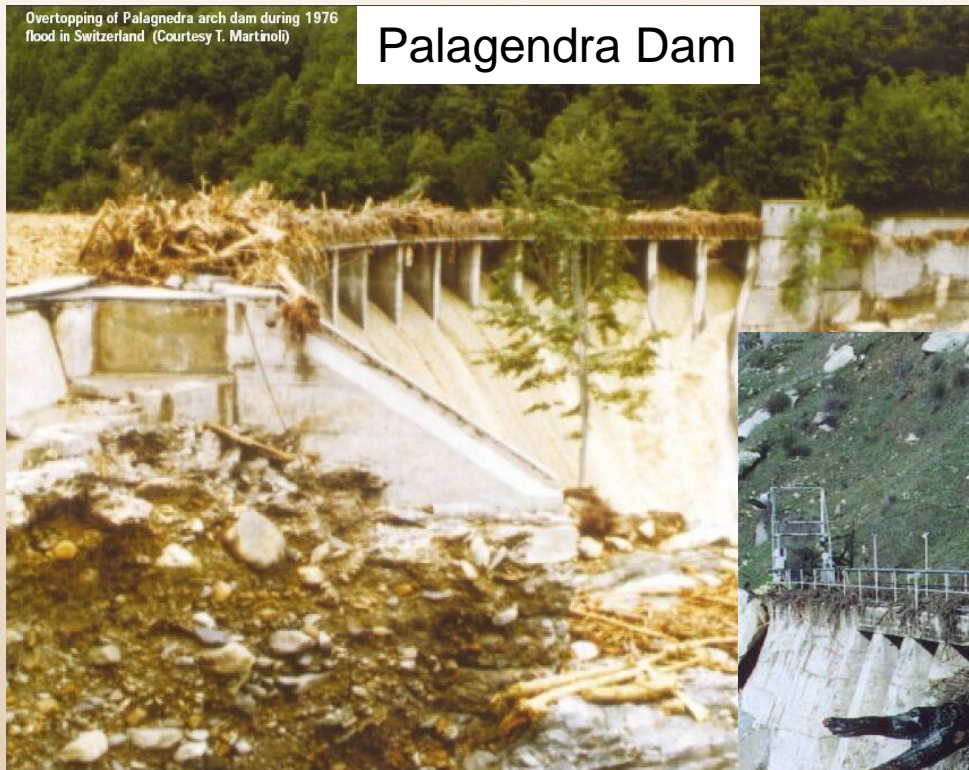
- 5 people in Ranger's house were miraculously thrown out of the way when the flood hit
- No one died



- Winter – campground not occupied
- No one died



# Picture of Dams with Debris





# Rock Fall Damages Spillway Gates





# Project Access



# Limit Switch Failure





# Spillway Operating Deck and Generator Floods



Emergency generator room  
same elevation as catwalk.



Catwalk almost inundated  
during flood – gates must be  
operated from catwalk



# Switchyard Floods – Loss of Power Release Capacity



# Other Mechanical/Electrical Related Failure Examples

- Valve failure



- Control valve left in open position leading to fully opened gate
  - Control valve not equipped with spring loaded lever
- Software error in SCADA syst. causes gate to open unexpectedly

# Insufficient Pump Capacity Inundates Leveed Area



Sugar Tree Bottom Levee System



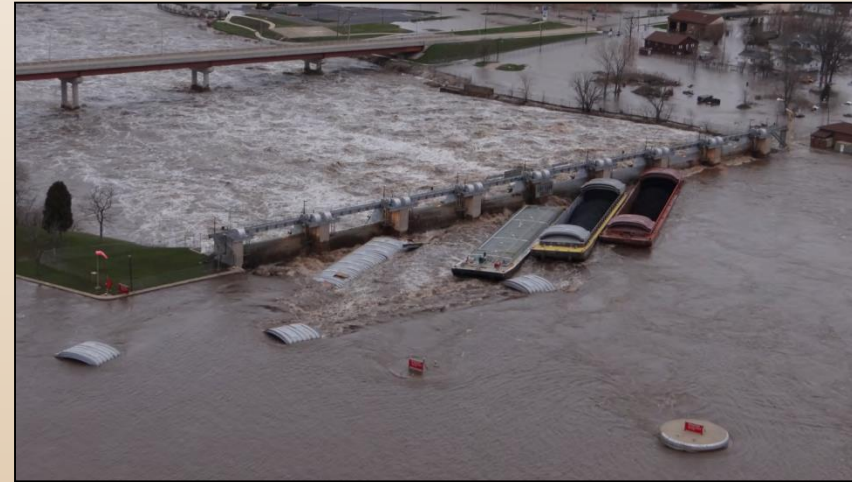
# Backflow Through Interior Drainage Culvert Due to Failure to Close Gate



Brookport Levee System

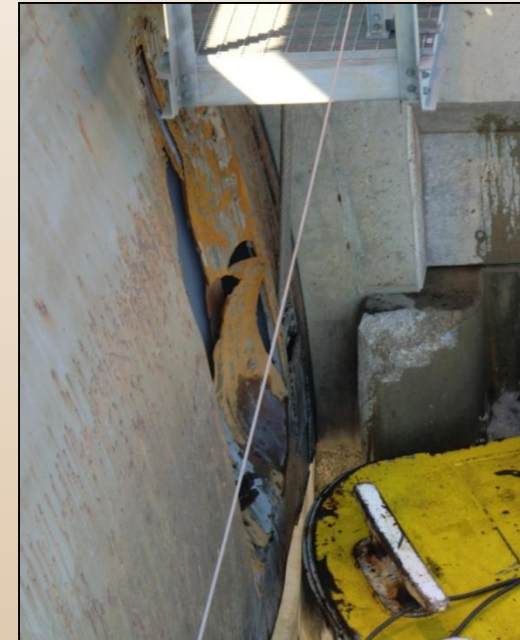
# Marseilles L&D, IL

## Incident 18-19 April, 2013





# Marseilles L&D, IL Tainter Gate Damage





# Marseilles Damage Summary

- Main Dam
  - Six barges break free and three sink.
  - Gates 2 through 6 impacted by barges leaving Gates 2 and 3 inoperable
  - Pier 2 trunnion anchorage destroyed
  - Decreased spillway capacity led to erosion at dam around boiler house
- Earth Dike (Note: this structure is upstream of the main dam)
  - Erosion of earth section
  - Widespread residential flooding



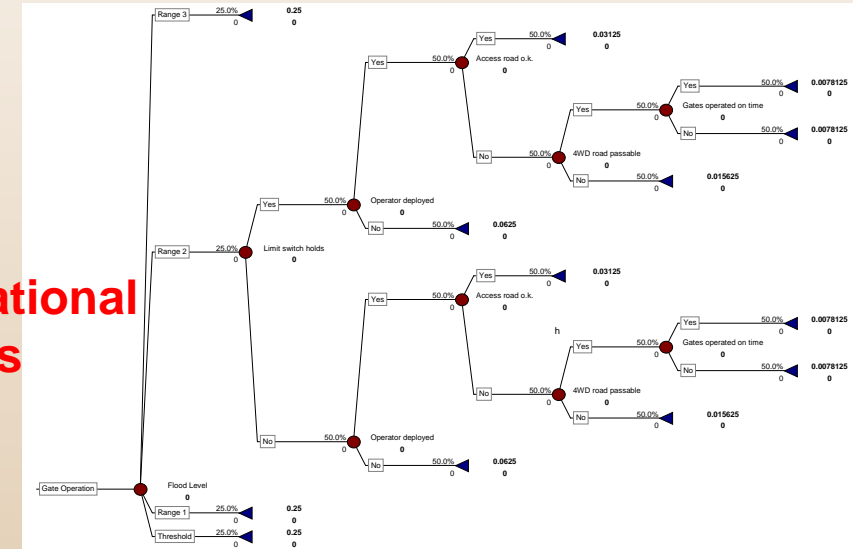
# Data on Spillway (Lack of) Release Incidents

- National Performance of Dams Database
  - 24 incidents related to debris plugging
  - 19 incidents related to structural failure
  - 25 incidents related to mis-operation
- FERC Incident database
  - 6 incidents related to debris plugging

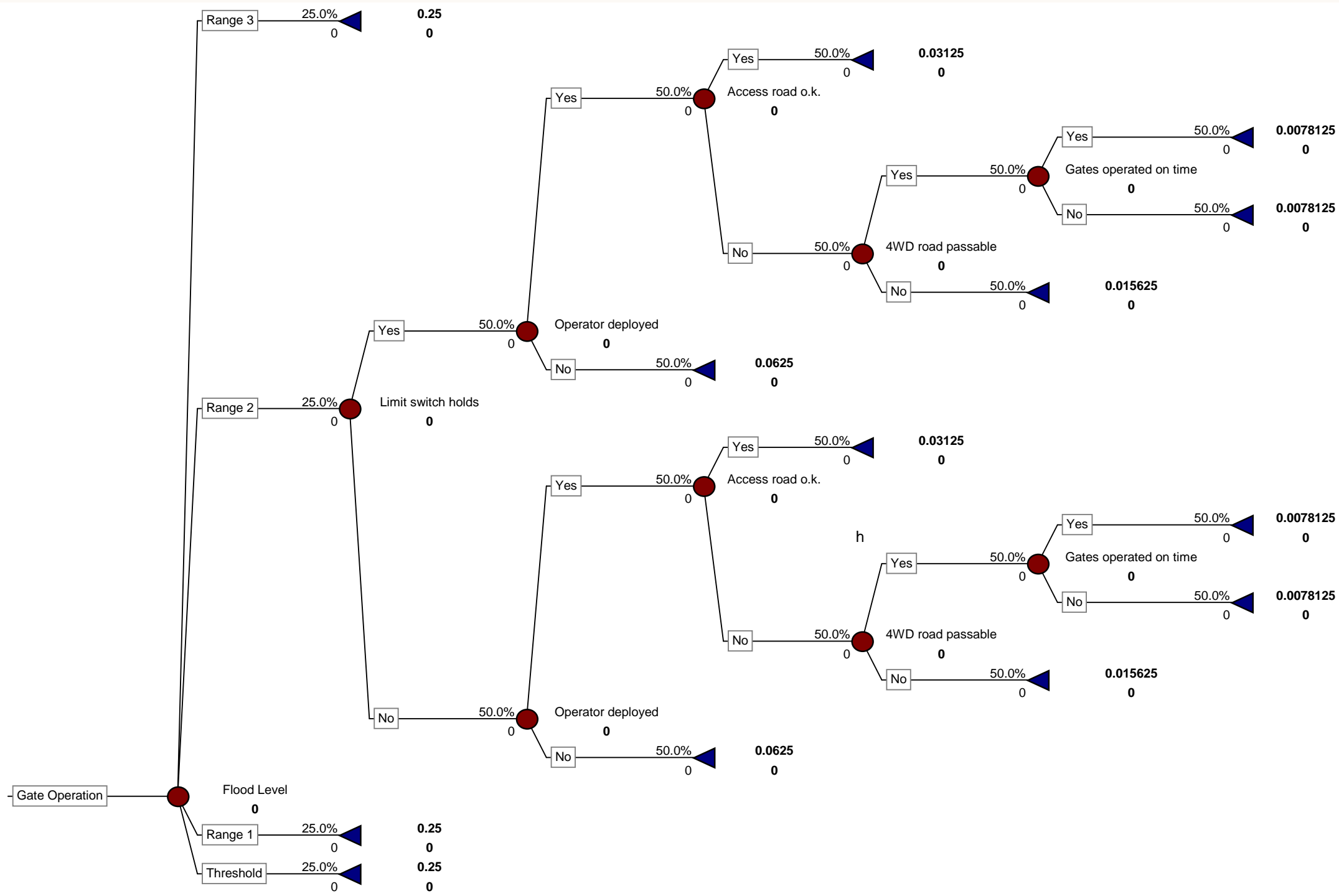
# Typical Portion of Event Tree

- ↳ Reservoir loading (partition)
  - ↳ Initiation - Limit Switch Fails
    - ↳ Operator Deployed
      - ↳ Main Access Road Impassable
        - ↳ Secondary (4WD) Road Impassable
          - ↳ Gates Not Operated on Time
            - ↳ Embankment Dam overtops
              - ↳ Erosion Initiates
                - ↳ Crest breaches
                  - ↳ Dam breaches (uncontrolled release of reservoir)

Operational events







# Questions



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